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(54) Gripper mechanism

(57) A gripper mechanism for use with a robot is arranged to withdraw items, preferably printed circuit boards 10, from a stack by using a solenoid actuated gripper 16 to grip the front edge of the item and then moving the gripper in a direction parallel to the plane of the item. The item is then supported on surfaces carried by a pair of lateral grippers 34,36, and the three grippers are then moved simultaneously relative to each other to position the item accurately with respect to the mechanism. Correct orientation of the item is ensured by engaging one of the opposed lateral sides at a single point 50, and the other at two spaced points 58,60, and the front edge at a point 32, each of the points being defined by a dowel. Movement of the grippers is brought about by rotation of threaded rods using servo motors 20,38.

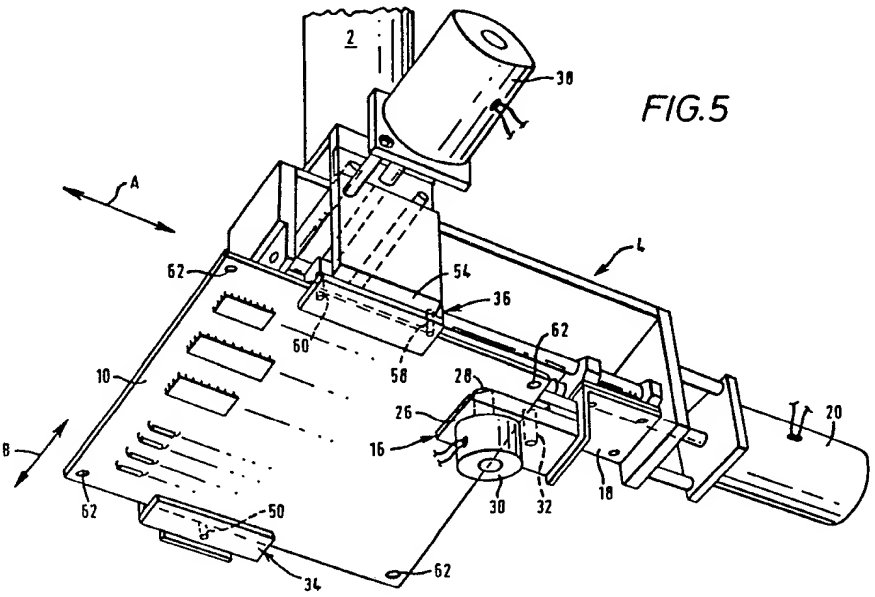

FIG.5

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FIG.1

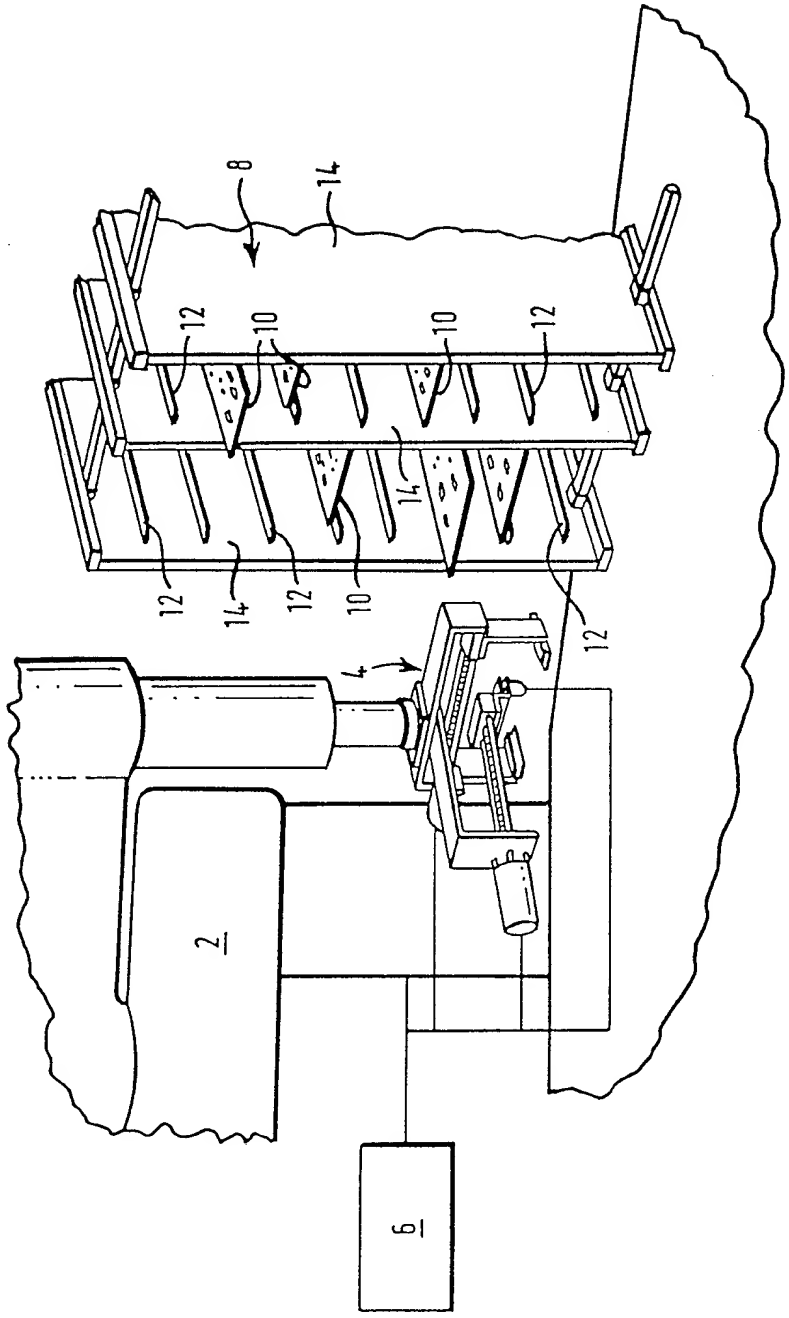

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FIG.2

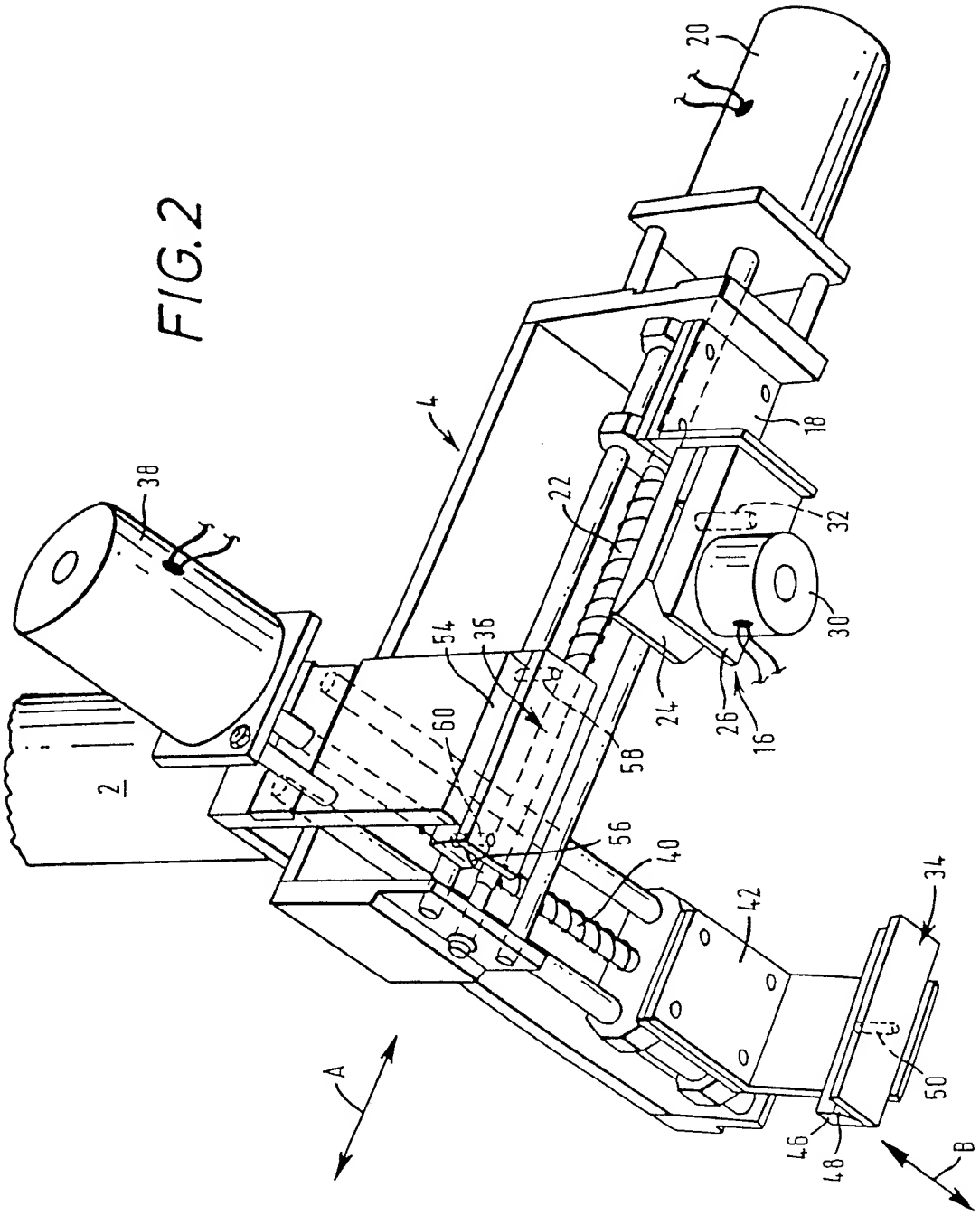


FIG. 2B

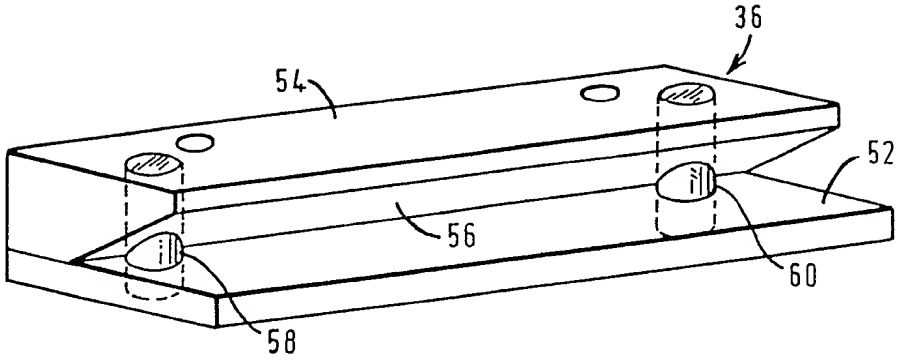
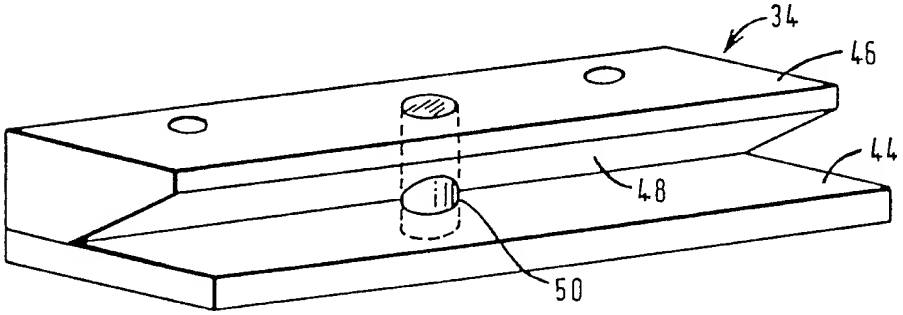


FIG. 2A



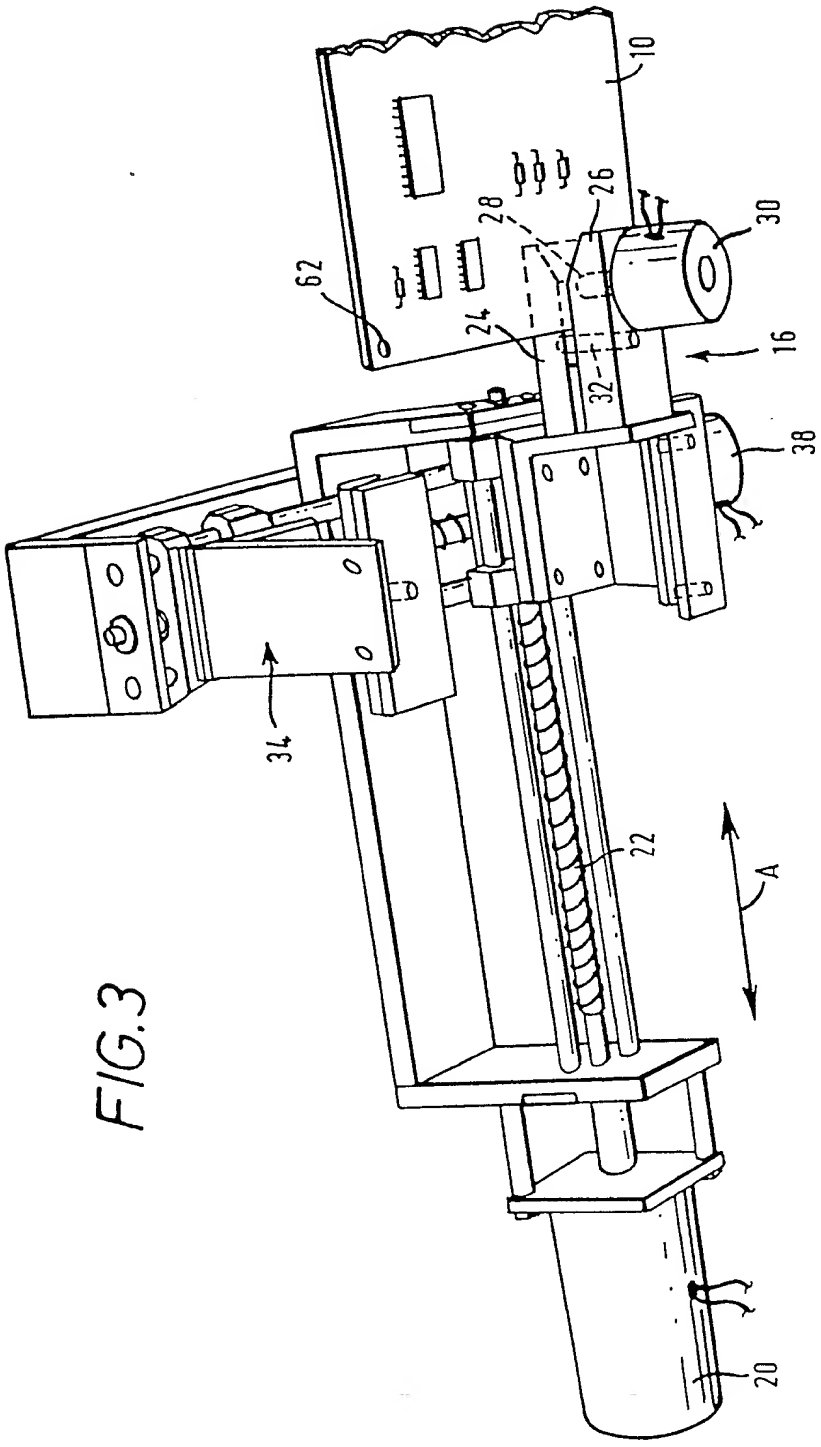


FIG.3

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FIG.4

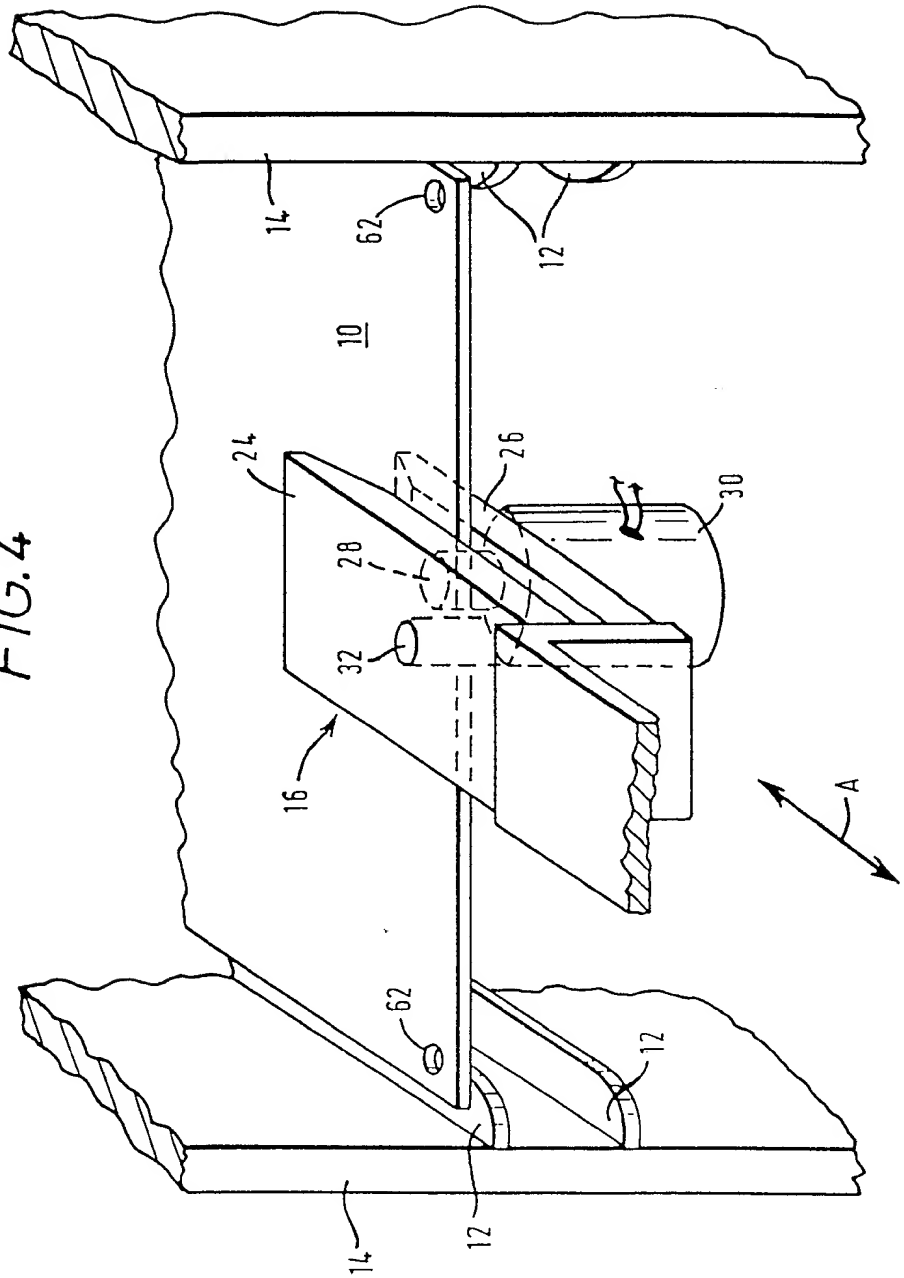
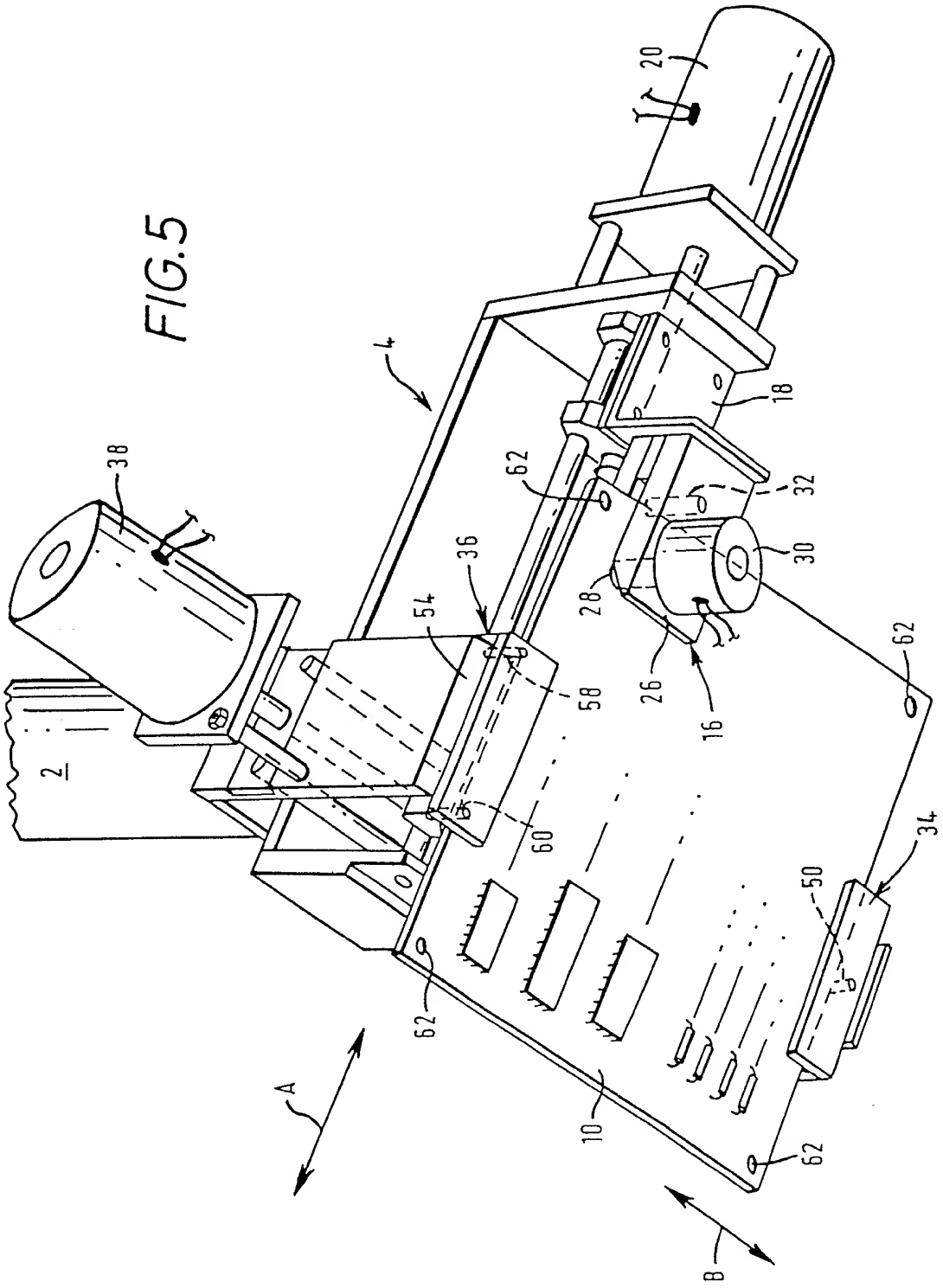


FIG.5



SPECIFICATION

Gripper mechanism

This invention relates to a gripper mechanism, preferably but not exclusively for use with a robot arm, and preferably but not exclusively for gripping and transporting substantially planar items such as printed circuit boards.

In the past, automatic mechanisms have been used to transport printed circuit boards to desired locations. Problems have been encountered in the supply of the printed circuit boards to these mechanisms. In particular, it has been necessary to ensure that the initial position of the printed circuit board is accurate so that it is reliably picked up and accurately positioned by the mechanism. Also, the techniques used to deliver printed circuit boards to the automatic mechanisms have been constrained by the requirements of the automatic mechanism and as a consequence have not been as convenient and economical as one would desire. Further, it has been difficult to provide convenient arrangements for handling items of different sizes.

In accordance with the present invention there is provided a gripper mechanism which is operable to take hold of an item the position of which may vary within a predetermined tolerance, and, while supporting the item, to position the item accurately with respect to the mechanism, preferably by simultaneously engaging two respective sides of the item in order to push the item to desired locations along two respective transverse axes.

In accordance with a more specific aspect of the invention there is provided a gripper mechanism comprising a gripper for taking hold of an item and placing the item on at least one support surface of the mechanism, and at least three engaging surfaces which are relatively movable to engage and move the item, while it is supported on said surface, along at least two transverse axes thereby to bring the item to a predetermined location with respect to the mechanism and allow the mechanism to transport the item accurately to a desired position.

The mechanism is particularly suitable for use in moving planar items, and especially printed circuit boards. Because the mechanism is able to position the item accurately after having gripped it, the initial position of the item does not have to be precise. In addition, because of this two stage gripping and positioning operation, there are fewer constraints upon the manner in which the items are presented to the mechanism, and it is easier to adjust the operation for items of different sizes. This is especially true of a preferred embodiment of the invention for use with planar items, wherein the gripper is arranged to take hold of the item by gripping an edge of it, and then to move in the plane of the item in order to place the item on the support surface of the mechanism. Using this embodiment, items can be initially located in a stack, which is particularly convenient and inexpensive arrangement. For example, standard adjustable printed circuit board racks can be used to support the printed circuit boards. The printed circuit boards can initially be placed on ledges in these racks either manually or automatically. In both cases, initial placement can be facilitated by adjusting the rack so that the side walls are spaced apart by greater amount than would be necessary for the accurate positioning of the board within the rack.

The mechanism is preferably attached to a robot arm which is controlled in a conventional manner. The mechanism may have individual parts which are moved by servomotors using conventional techniques.

The mechanism may be used to position the printed circuit boards for the insertion and/or soldering of components, and/or for fitting the board into an electronic assembly.

An arrangement embodying the invention will now be described by way of example with reference to the accompanying drawings, in which:

Figure 1 shows a system for transporting printed circuit boards to desired locations, the system incorporating a gripper mechanism according to the present invention;

Figure 2 is a perspective view from below and one side of the gripper mechanism;

Figures 2A and 2B are further views showing respective lateral grippers of the mechanism;

Figure 3 is a perspective view from below and the other side of the gripper mechanism, showing the state of the mechanism as it commences to withdraw a printed circuit board from a rack;

Figure 4 is another view of the gripper mechanism in the state shown in Figure 3; and

Figure 5 is a view of the mechanism similar to that of Figure 2 showing the printed circuit board after it has been located at a desired position with respect to the mechanism.

With reference to Figure 1, a system for transporting printed circuit boards to predetermined locations comprises a standard robot arm indicated at 2 which carries a gripper mechanism 4 according to the invention. A control unit 6, which may be a general purpose computer, controls the robot arm in a conventional manner so as to shift the gripper mechanism 4. The robot arm 2 is capable of moving the gripper mechanism 4 in substantially any direction in the horizontal plane, as well as moving the gripper mechanism vertically and turning the mechanism about a substantially vertical axis.

The control unit 6 is also coupled to actuators (described further below) of the gripper

mechanism 4 to control the gripping operation.

An adjustable printed circuit board rack 8, of a well known type, carries stacks of printed circuit boards. Each printed circuit board 10 rests on a pair of ledges 12 on respective walls 14 of the rack 8. In Figure 1, for the purposes of clarity only a few of the printed circuit boards 10 and ledges 12 have been shown. In practice, the boards 10 would be more closely spaced. The ledges 12 could alternatively be slots between which the boards are inserted.

This use of racks is a quite conventional arrangement for storing printed circuit boards. However, it is not conventional to use such racks when the boards are to be retrieved automatically, rather than manually. Automatic retrieval conventionally requires very accurate positioning of the printed circuit boards. However, using a gripper mechanism of the present invention, the printed circuit boards do not need to be positioned accurately prior to automatic retrieval. Indeed, the walls 14 of the rack 8 can be adjusted so as to allow a large degree of variation in the lateral position of the boards (up to the width of one of the ledges 12). Also, the longitudinal position of the boards, i.e. the distance between the front of the rack 8 and the front edge of the board, can vary substantially, as indicated by the boards shown in Figure 1.

The gripper mechanism 4 is operable to approach the rack 8, grip a selected one of the boards 10, withdraw the board 10, accurately position the board with respect to the mechanism, and transport the board to a further location (not shown) where the board can be accurately positioned for an operation to be performed on it. The board is then replaced in its original position in the rack 8, preferably using the same gripper mechanism 4, before another board 10 is removed. The transportation of the board by the gripper mechanism 4 and the accurate positioning of the board with respect to the gripper mechanism 4 can take place in any desired sequence, and indeed this positioning could take place while the gripper mechanism is moving the board toward the desired location.

The gripper mechanism 4 is shown in more detail in Figure 2. The mechanism comprises a longitudinal gripper 16 which is supported on a carriage 18. The carriage 18 and thus the gripper 16 can be reciprocated in the direction A by a servomotor 20 which is controlled by the control unit 6 to rotate a threaded rod 22 which cooperates with the threaded interior of the carriage 18.

The gripper 16 comprises two legs 24, 26 with a gap therebetween for receiving a printed circuit board. The entrance to the gap is tapered to facilitate insertion of the printed circuit board. The printed circuit board can be held between the legs 24, 26, by the armature 28 (see Figure 5) of a solenoid 30 which is also controlled by the control unit 6. A dowel pin 32 positioned at the rear of the slot formed between the legs 24 and 26 serves to locate accurately the front edge of the printed circuit board, as will be described.

The gripper mechanism 4 further comprises lateral grippers 34 and 36 (see also Figures 2A and 2B). The gripper 36 is fixed, and the gripper 34 can be reciprocated in the direction B by operation of a second servomotor 38 controlled by the control unit 6. This is achieved by rotating a threaded rod 40 which engages the threaded interior of a carriage 42 of the lateral gripper 34.

The gripper 34 has a lower flange the upper surface 44 of which will be used as described later to support the printed circuit board. An upper member 46 of the lateral gripper 34 has an inclined, generally downward facing surface 48, so that a gap is formed between the surfaces 44 and 48 for receipt of an edge of the printed circuit board. A dowel pin 50 extends between these surfaces, and serves to position accurately the edge of the printed circuit board, as will be explained.

The lateral gripper 36 has a structure which is very similar to that of the gripper 34, including a support surface 52, and an upper member 54 with an inclined surface 56. In this case, however, the gripper 36 has two spaced dowel pins, 58 and 60, instead of the single dowel pin 50.

Referring to Figures 3 and 4, in order to take hold of a printed circuit board the servomotor 20 is actuated to drive the longitudinal gripper 16 in the horizontal direction A after the gripper mechanism 4 has been brought in front of the rack 8 and positioned at a predetermined height. The front edge of the printed circuit board 10 thus enters the space between the legs 24 and 26 of the gripper 16. Depending upon the precise position of the front edge of the printed circuit board 10, the board may or may not come into contact with, and be moved backwards by, the front engaging surface of the dowel pin 32.

After the gripper 16 has been driven forward by desired amount, the solenoid 30 is actuated to cause the armature 28 to engage the underside of the printed circuit board 10 and thus grip the printed circuit board against the leg 24.

The servomotor 20 is then driven to retract the gripper 16 and thus the printed circuit board, which is drawn between the two lateral grippers 34 and 36. At the completion of this movement, the lateral edges of the printed circuit board 10 rest on the support surfaces 44 and 52 of the lateral grippers 34 and 36.

This action of withdrawing the printed circuit board from the rack 8 involving merely gripping the front edge of the printed circuit board and moving the gripper in a direction parallel to the plane of the board, enables

relatively close stacking of the printed circuit boards in the rack 8 without interfering with access thereto.

It will be noted from Figure 4 that there is a substantial amount of space between the lateral edges of the printed circuit board 10 and the side walls 14, and as a consequence of this the lateral position of the board 10 may vary somewhat (say up to 3 mm if this is the ledge width) when the board is gripped by the gripper 16.

For the same reason, the precise orientation of the board may vary.

The gripper mechanism is accordingly next operated for precisely positioning the board with respect to the mechanism. Firstly, the solenoid 30 is controlled by the control unit 6 to release its grip on the board 10. Then, both the servomotors 20 and 38 are driven simultaneously, so that the gripper 16 is moved to the upper left as shown in Figure 5 and the gripper 34 to the upper right.

The relative lateral movement of the grippers 34 and 36 causes the two lateral opposed edges of the board 10 to be gripped between the dowel pin 50 on the one hand and the dowel pins 58 and 60 on the other hand. The use of three points of contact, with the two on one side positioned on opposite sides of a line drawn parallel to the direction B of movement through the point on the other side, ensures not only that the board is correctly positioned laterally, but also that it is correctly oriented. The simultaneous movement of the gripper 16 ensures that the front edge of the dowel pin 32 engages the front edge of the board 10, if it is not already so engaged. This is preferable because it removes the need for ensuring engagement of the dowel pin with the front edge of the board during initial gripping of the board, and also ensures that the reorientation of the board by the pins 50, 58 and 60 does not effect the longitudinal positioning of the board.

As a result of this operation the precise position of the edges of the board with respect to the gripper mechanism are determined. Because the board 10 is provided with mounting holes such as those shown at 62 which are precisely located with respect to the edges, the board can then be accurately moved to and positioned on tooling pins provided for locating in the holes 62. During subsequent retrieval of the board from the tooling pins, the step of accurately positioning the board with respect to the gripper mechanism may not be needed, because the boards initial position will probably be accurately known. Instead, the gripper mechanism may be controlled simply to reverse the movement which it executed to deposit the board in its desired location.

As indicated in Figure 1, the boards 10 may have different widths. There may be several stacks of boards (only two being shown in Figure 1), each stack containing boards of a respective width. Adjusting the operation of the gripper mechanism to cope with boards of different widths is simply a matter of ensuring that the initial separation of the lateral grippers 34 and 36 is appropriate for the board width. Preferably, before withdrawal of the printed circuit board 10, the engaging surfaces formed by the dowel pins 50, 58 and 60 are laterally separated by an amount which is very slightly greater than the separation between the side walls 14 between which the board 10 is located. The correct separation can be achieved simply by programming the control unit 6 with the appropriate board width, or by providing some form of sensor for detecting the board width (or the spacing between the walls 14).

Instead of using servomotors to drive the grippers, and controlling the motors in response to feedback signals, ordinary motors can be used and driven for controlled periods determined by the board size.

In the embodiment described above, after accurate positioning of the board, the board is primarily held by the engagement of opposed edges by the lateral grippers 34 and 36, and the force with which it is held is determined by how accurately the lateral gripper 34 is positioned. This should be fairly easy to achieve, having regard to the small variation in board width and the accuracy of servomotor control which would be expected. If desired, however, a spring arrangement can be used so that one or both of the opposed edges of the printed circuit board can be resiliently engaged to ensure the board is securely held. However, if this is done then the degree of resilient movement permitted by the spring arrangement should preferably be not substantially greater than the expected variation in board width, so as not to affect significantly the accurate positioning of the board. As a further alternative the motor 38 used to drive the gripper 34 could be controlled so that the gripper 34 is driven more than is necessary. The motor 38 would stall once the board is firmly held between the grippers 34 and 36.

It is desirable for the grippers 16 and 34 to be moved simultaneously during the accurate positioning of the board. It is particularly desirable for the movements to be timed so that they end at substantially the same moment. If the gripper 16 continues to move after the gripper 34 has completed its movement, problems may be encountered due to the frictional engagement of the opposed edges of the printed circuit board. However, this may not be a serious problem because using the embodiment described above there are only small areas of contact and therefore there will be little friction. However, if the lateral gripper 34 continues to move after the longitudinal movement of the gripper 16 has terminated, this may alter the orientation of the board and thus upset the accurate longitudinal positioning

of the board.

Various other modifications and developments may be made to the mechanism and method described above. For example, each gripper 16, 34, 36 may be fitted with a sensor, such as an optical sensor, which provides an electrical output signal dependent upon whether or not a board is present in the respective gripper, in which case the control system is responsive to such signals and can activate an alarm signal if, when a board is expected to be present, not all of the sensor signals indicate that a board is present. Also the gripper 16 may be assisted by a further gripper arranged to grip the same edge of the board as the gripper 16 at a location spaced along that edge from the gripper 16.

CLAIMS

1. A gripper mechanism comprising a gripper for taking hold of an item and placing the item on at least one support surface of the mechanism, and at least three engaging surfaces which are relatively movable to engage and move the item, while it is supported on said surface, along at least two transverse axes thereby to bring the item to a predetermined location with respect to the mechanism and allow the mechanism to transport the item accurately to a desired position.

2. A mechanism as claimed in claim 1, wherein two of the engaging surfaces are arranged to engage respective opposed sides of the item so as to grip the item therebetween.

3. A mechanism as claimed in claim 2, having at least two support surfaces on which the item is placed by the gripper and each of which is fixed with respect to a respective one of the engaging surfaces arranged for engaging opposed sides of the item.

4. A mechanism as claimed in claim 2 or 3, including an additional engaging surface for engaging one of said opposed sides of the item, whereby relative movement between the two engaging surfaces at one of the opposed sides and the engaging surface at the other opposed side to grip the item tends to cause the item to adopt a predetermined orientation.

5. A mechanism as claimed in claim 1 or claim 2, wherein one of the engaging surfaces is carried by the gripper.

6. A mechanism as claimed in claim 5 when dependent upon any one of claims 2 to 4, wherein the engaging surface carried by the gripper is operable to position the item along a first of the axes, and the other engaging surfaces are arranged to position the item along the other axis and to hold the item therebetween.

7. A mechanism as claimed in any preceding claim, suitable for gripping substantially planar items, wherein the gripper is arranged to clamp an edge of an item in order to take hold of it.

8. A mechanism as claimed in claim 7, wherein the gripper is movable substantially in the plane of the item in order to take hold of the item and to place it on said support surface.

9. A mechanism as claimed in any preceding claim, wherein the gripper and/or at least one of the engaging surfaces is provided with a sensor to provide a signal indicative of whether or not a item is present thereat.

10. An item transporting system comprising a mechanism as claimed in any preceding claim, and a control means arranged to control the operation of the mechanism.

11. A system as claimed in claim 10, where the control means is arranged so as to cause two of said engaging surfaces to move simultaneously relative to each other and to the third of the engaging surfaces in order to move the item to the predetermined location.

12. A system as claimed in claim 11, wherein the control means is arranged so as to terminate the relative movement of all three support surfaces at substantially the same time.

13. A system as claimed in any one of claims 10 to 12, wherein a robot arm is provided for supporting and moving, under the control of said control means, the gripper mechanism.

14. A method of moving items using a transporting system as claimed in any one of claims 10 to 13, the method comprising taking hold of an item using the gripper of the mechanism, accurately positioning the item with respect to the mechanism by producing relative movement of the engaging surfaces and moving the mechanism in order to transport the item to a desired position, and then causing the mechanism to release the item.

15. A method as claimed in claim 14, wherein the item is substantially planar.

16. A method as claimed in claim 15, wherein the item is a printed circuit board.

17. A method as claimed in claim 15 or 16, the method being used to remove a plurality of items in a stack each to a desired location.

18. A method as claimed in claim 17, including the steps of replacing the items in the stack.

19. A method as claimed in claim 18, wherein the items are moved in succession, and each item is moved and replaced before the next item is moved.

20. A method as claimed in any one of claims 17 to 19, wherein the items are of different sizes.

21. A gripper mechanism substantially as herein described with reference to the accompanying drawings.

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